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HOW VITROLITE GLASS IS DECORATED

Near Parkersburg, W. Va., the Libbey-Owens-Ford Glass Co. maintains a completely equipped decorating department in which strikingly beautiful effects are achieved by combinations of colored glasses and mirrors, together with sandblast relief.

Although decorated glass is still too new to have reached impressive proportions, the attention accorded some the better known installations has demonstrated a degree of public acceptance and enthusiasm that augurs well for its future. The development of this type of ware should prove of major interest to all glass men, not alone from the standpoint of artistic achievement but for the decorating technique involved.

The present discussion will deal with both of these phases, and our demonstration will be made with the help of the Forum Cafeteria, Chicago, from which several interior views have been photographed by way of illustration. The Forum installation combines colored glass panels, mirrors and decorated glass with quite extraordinary results. It was designed in cooperation with Frank Sohn, glass technician of the Libbey-Owens-Ford Company. The colored and decorated glass was produced by the Vitrolite Division of that company.

Several types of decorated work are produced at the Vitrolite Division including: (1) "Inlaid," in which pieces of colored opaque glass and tinted mirror glass are fitted and cemented into sandblasted depressions in the colored Vitrolite panels; (2) "Laminated," in which thicker pieces are set in the background panel and project above the panel surface; (3) "Colored," which carries a lightly sandblasted design colored with a suitable pigment; (4) "Relief Sandblast," clear plate glass with a sandblasted design on the back and the front smooth; (5) "Dull Tone," lightly sandblasted designs, often on black glass, for fluted panels, table tops, etc; (6) "Grilles," panels in which parts of the design are sandblasted all the way through the plate; (7) "Dendric," or glue-chipping, in which a special glue process produces an interesting veined surface. The importance of the sandblasting operation in the great majority of the decorative techniques is immediately apparent.

One wall of the Forum installation is shown in Fig. 1, this view illustrating a very acceptable procedure for utilizing "inlaid" decorations on a Vitrolite panel wall. The plain panels are in the color known as jade agate, the wainscote is sun-tan, and a belt of cadet-blue forms the base of the wall. The "inlaid" murals show pictorially the gathering of various food products in different parts of the world and the coloring is remarkably natural. A closer view of the mural depicting the gathering of bananas by natives in the West Indies is shown on the front cover. Here one may identify some of the small pieces of glass which have been embedded in the jade-agate background panels to form the attractive decorative design.

Since inlaid work is one of the most complicated and exciting of the Vitrolite decorating processes, it will be of interest to follow this process throughout. The design is, of course, the first step and this is originated in the L-O-F art department in Toledo. The artist has available a great variety of opaque, colored and inlay glasses, as well as several shades of tinted mirror glass, a total of thirty-two. Background panels are of colored Vitrolite, either 11/32 or 7/16 in. in thickness, and are available in 16 colors as follows: White, black, gray, ivory, sun-tan, red, tropic green, princess blue, cadet blue, orchid agate, royal blue agate, walnut agate, emerald agate, yellow, jade, and jade agate. The beautiful agate effects in this list are produced by the heterogeneous mixture of different colored glasses in the molten form before the plate is rolled and all of these Vitrolite colors are manufactured by Libbey-Owens-Ford. The thinner (3/32 in.) opaque colored inlay glasses, on the other hand, come mostly from European producers, but the tinted mirror sheet for inlay work is produced in this country.

After the design is received at the Parkersburg plant it must be reproduced full size in readiness for sandblast stencil cutting. At present this reproduction is made in the drawing room, but apparatus is now being installed to make the full-size reproductions photographically. The

Fig. 1. One wall of the Forum Cafeteria in Chicago showing Vitrolite glass wall with inlaid pictorial decorations.

Fig. 2. Stencil material is placed on the Vitrolite panel in which the design is to be sandblasted and the stencil then is cut very carefully by hand.

Fig. 3. Cutting the glass panel for "inlaid" or "laminated" decorations is accomplished with a heavy sandblast gun using a large quantity of sharp sand or Aloxite.

Fig. 4. The operator at the left is cutting small blanks of inlay glass. The other man is shaping the blanks very carefully to fit into the sandblasted recesses of the background panel. On the table can be seen the partially finished center panel of the mural shown in the front cover illustration.

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background panel is now covered with the stencil material and the design is carefully cut in the stencil by hand. Fig. 2 shows the operator giving the final touches to such a stencil on a royal blue agate panel and, with the completion of this operation, the panel is ready for sandblasting. For inlaid work the portions of the Vitrolite glass not covered by the stencil are sandblasted to a depth of 3/16 in. and Fig. 3 is a view in the sandblast booth during the cutting of the eagle design in the blue panel.

The shaping of the inlay pieces of colored glass is hand work of the most exacting kind. In Fig. 4 one operator is cutting blanks to approximate size from the proper color of inlay glass, these small blanks then being carefully shaped and bevelled by the operator at the abrasive-belt machine. On the table in this view can also be seen the sandblasted center panel of the banana-gathering mural (see cover). The sides of sandblasted depressions are not perpendicular nor are the bottom corners square, so the pieces of inlay glass must be bevelled on the bottom all around to clear the fillet at the bottom of the depression and permit a continuous film of cement between the inlay and the background panel. At the surface of the panel the inlays fit the outlines of the depression exactly. Not all of the inlaid pieces are plain in color, since it is sometimes necessary to decorate the inlays themselves with color or light sandblast to give the desired effect.

Another very appropriate use of inlaid decorating work is the making of glass signs for store fronts, these signs having Vitrolite panel backgrounds similar to the mural decorations just described. The technique of manufacture is also similar, although the inlaid pieces are in general much larger. In Fig. 5 a portion of one of the letters for a sign is being shaped and bevelled and in Fig. 6 an inlay is being fitted into a sandblasted depression in the royal blue agate background plate. In Fig. 7 the finished inlaid panels are being assembled on the floor of the decorating department for final inspection before shipment.

The "laminated" decorating technique is quite similar to that for the "inlaid" variety, the only practical dif-

ference being that in the finished work the inset pieces project above the surface of the background plate instead of remaining flush. Laminated decorating is used for signs and similar work. The background plate is sandblasted to a depth of about ⅛ in. and in this case the inset pieces are of Vitrolite, mostly 11/32 in. thick but sometimes 7/16 or even ¾ in. When large pieces of the heavy ¾-in. Vitrolite are inset, they are often held in place by means of special anchor bolts as well as cement. For the "colored" variety of decoration, the design is sandblasted into the background plate only a scant 1/32 in. deep and the sandblasted areas are then colored, a weatherproof varnish being used for outdoor installations and a lacquer for indoor work.

Some of the most striking effects are secured by the use of the "relief sandblast" in which the design is sandblasted on the back of clear polished plate glass. This type of decoration was used with great success in the Forum installation. A panel depicting the gathering of oranges and the ceiling decoration are shown in Fig. 8 and a closer view of another panel showing the gathering of coffee appears in Fig. 9. Work of this nature calls for the closest sort of cooperation between the artist, the stencil-cutter and the sandblast operator, as well as great care and skill at each step in the process and is performed by L-O-F for its dealers who have not satisfactory local facilities. This kind of relief work has definite artistic limitations, so it is necessary that

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Fig. 5. This operator is beveling a piece of opal glass to be used in making an inlaid sign.

Fig. 6. The next step in the making of the inlaid Vitrolite sign is to fit and cement the inlays carefully into sandblasted recesses in the background panels.

Fig. 7. Finished inlaid sign panels are assembled for final inspection. In this sign the letters are opal and the background is royal blue agate Vitrolite.

the artst produce a design that falls within the possibilities of the technique. The relief work stencil is necessary for the production of sharp edges and lines and is also used to mask areas at different depths in the relief.

The stencil is cut in reverse, since the design is to be seen through the glass, and the sandblast operator uses a small gun, as in Fig 10, in much the same way that an artist uses an airbrush. The blasting operation seems incredibly complicated to the uninitiated as the operator goes coolly along, carrying each segment of surface to the proper depth, providing roundness where necessary, and removing pieces of the stencil here and there as the work progresses. It is almost unnecessary to state that a new stencil is required for each panel produced by the "relief sandblast" process.

Another form of decoration produced entirely by sandblast is the "dull tone" variety. It is achieved by means of very light sandblasting on the surface of colored Vitrolite, often black, and is used largely on decorative panels and table tops, in which applications it can be used for designs and shaded work, and also resists scratching. In Fig. 11 the operator is sandblasting "dull tone-' flutes on a black Vitrolite panel. At the start the panel is entirely covered with strips of stencil material, the strips being held in position by steel bars. As the sandblasting on each flute to indicate roundness is finished, the next strip of stencil is removed and the fluting is continued until the entire surface is finished.

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Fig. 8. These decorative panels in the Forum installation are produced by relief sandblast, a technique by which the design is sanded into the back of clear plate glass panels and then viewed from the front.

Fig. 9. A closer view of one of the relief sandblast panels, showing the lively beauty of this decoration and the results of skillful stencil and sandblast technique.

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Vitrolite decorative grilles are formed by sandblasting the design clear through the plate, as illustrated in Fig. 12. In this picture the grille at the left was made from red Vitrolite and the other from black. Such grilles are often used to good effect as ventilation openings in the bulkheads of Vitrolite store fronts.

In addition to the six varieties of decoration described, there is one other which has been very popular but has lately given way in a degree to the others. This is the "dendric" surface decoration. It is produced by a process known as glue-chipping, in which the surface of a panel is coated with a special glue and dried at 110 deg. F. As the glue dries it pulls away from the glass taking fine chips along with it and leaving a finely veined surface that appears soft in texture and is very effective in many colors.

In all of these decorating techniques the results obtained depend almost entirely on the skill of the operators in the various steps of the work and the type of

equipment used is of relatively minor importance, but the selection of some of the equipment and materials is of sufficient interest to deserve some further detailed attention. In the very important sandblast department, for instance, three kinds of equipment and various abrasive materials are used. In "dull tone" decorations it is only necessary to produce a cloudy effect on the surface of the glass, as shown in Fig. 11, and this requires only a small amount of fine sand as an abrasive. The gun used in this work has a suction feed. On the other hand, the much deeper sandblasting needed for inlaid and laminated work and grilles requires much heavier equipment and a pressure feed for the abrasive, as shown in Fig 3. This heavy cutting uses a large amount of sharp sand or a medium size of Aloxite grain. Finally, the little gun used for the "relief sandblast" operation, shown in Fig. 10, utilizes a considerable quantity of fine sharp sand as an abrasive and has an orifice only 1/16 in. in diameter.

The stencil materials for the sandblast work are of almost equal importance, since it is necessary for them to absorb a terrific amount of punishment in some of the deeper sandblasting operations without showing the slightest deterioration. Otherwise, fine lines and sharp edges in a design would be impossible of execution. Stencils can be generally classified in two categories, "tied" and "untied." The tied stencil is familiar to everyone in the form of the well-known brass marking stencils in almost any shipping room. This type of stencil is used for certain formalized designs for borders, etc., but the great majority of the Vitrolite decorations require the "untied" sort of stencil and it follows that every piece made has to have a new stencil.

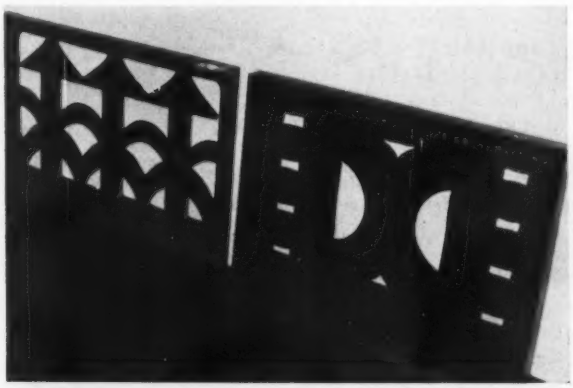
For the deeper forms of sandblasting at Vitrolite, stencils are cut from standard Scotch sandblast stencil material, tough rubbery stuff which clings to the surface of the glass like a poor relation. For the lighter sanding operation, such as those for laminated and colored decorations, ordinary 1/16-in. black gasket rubber may be used for tied stencils and the regular Scotch masking tape is satisfactory for the untied variety. For dull tone decorations the stencil does not receive very rough treatment and ordinary tagboard is used for these stencils with satisfactory results. Great numbers of stencils made at Vitrolite and used through its many years of business life are stored in fireproof vaults, as shown in Fig. 13. These stencils may, of course, be used at any time to duplicate designs previously produced.

Fig. 10. In producing relief sandblast a small gun with a 1/16-in. orifice is used in much the same manner as an artist's airbrush.

Fig. 11. This sandblast operator is producing "dull tone" flutes on a black Vitrolite panel. This gun uses a small amount of sand and has a suction feed.

Fig. 12. Red (left) and black grilles are produced by sandblasting a design clear through Vitrolite panels.

Fig. 13. P. M. (Pete) Hull, foreman of the Vitrolite decorating department, looks over a few of the thousands of stencils stored in vaults at the Parkersburg plant.



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PRODUCTION FIGURES FOR THE GLASS INDUSTRY DURING SEPTEMBER, 1939

Plate Glass: The total production of polished plate glass by member companies of the Plate Glass Manufacturers of America during September, 1939, was 13,662,855 sq. ft., as compared to 10,450,189 sq. ft. produced in the preceding month, August, 1939, and 8,873,344 sq. ft. produced in September, 1938. This makes a total of 89,082,689 sq. ft. produced during the first nine months.

Window Glass: During September, 1939, the production of window glass was 913,980 boxes, which represents 56.2 per cent of industry capacity. As compared with this, September, 1938, production was 522,145 boxes, representing 32.1 per cent of industry capacity.

Glass Containers: Production of glass containers by members of the Glass Container Association during the month of September, 1939, was 4,249,945 gross, bringing the total for the nine months of this year to 37,982,036 gross. Shipments for September were 4,978,504 gross, bringing the total for the year to 37,682,600 gross.

Other Glass Products: September production of glassware other than containers, window and plate had a value in round numbers of $8,000,000. This compares with $6,000,000 of a year ago.

Comment: As the returns come in from its various branches, it becomes evident that the glass industry in its entirety is in excellent shape at the three-quarter mark period. Glass container production shot upward in September, registering about a 19 per cent increase over 1938 and making this the second biggest month in the history of the industry and the best September. A new banner year is within striking distance. Increased activity has been most noticeable in the wide mouth food lines, both pressed and blown. Individual manufacturers reporting to THE GLASS INDUSTRY in late October indicate that the boom is still continuing into the final quarter. It should be noted that shipments have almost balanced production, showing that the present increase has been effected without any appreciable accumulation of inventories that might weaken the future situation.

The September upsurge was not confined to containers but was felt in all lines, even discounting the seasonal improvement normal to them. In plate glass, September was the second biggest month of the year. Demand from building, automotive and mirror sources have been strong, 1939 car models are showing larger windshield areas, and this with an increase of 42 per cent in sales of motor units (46 per cent increase in passenger vehicles) has called for more glass. Window glass production is 75 per cent ahead of September and about 80 per cent over the nine month period of 1938.

The only glass industries compiling and releasing official figures of production are the container, plate and window manufacturers. To complete the picture of the industry as a whole, THE GLASS INDUSTRY has compiled its own totals of other types of ware from sources it considers thoroughly reliable. The production of these other items is very close to $8,000,000, a gain of 33 1/3 per cent over 1938. Much of these gains can be traced to the improved situation in the pressed and blown field, where declining imports and expanding exports have been definitely contributing factors.

FOREIGN TRADE OPPORTUNITIES

The Bureau of Foreign and Domestic Commerce of the Department of Commerce regularly publishes specific export trade leads in the form of "Foreign Trade Opportunities." In a recent bulletin of that Department it was reported that "during 1938, the Specialties Division of the Bureau of Foreign and Domestic Commerce published 120 export trade opportunities based on inquiries of firms desiring to purchase or obtain agencies for the sale of American glass products. These were classified as follows: tableware (50); containers (32); flat glass (11); miscellaneous types (27). We have been told that few American glass manufacturers have followed up these trade leads, with the result that many of the inquiring firms have failed to make a satisfactory contact."

THE GLASS INDUSTRY believes many glass manufacturers were unaware of the existence of these trade leads and has obtained permission from the Department of Commerce to republish the announcements. Interested American firms may obtain the names and addresses of the foreign firms making these inquiries upon application to the Bureau of Foreign and Domestic Commerce or any of its District or Cooperative offices. The following announcements were made during the period September 1st-October 21st:

Reference Number	*Commodity*	*City and Country*	*Purchase or Agency*
3612	Bottles for perfumery, milk and beverages	Santiago, Cuba	Agency
3678	"One way" glass	Habana, Cuba	Purchase
3671	Shatterproof glass for automobiles	Glasgow, Scotland	Both
3658	Glassware	Rio de Janeiro	Agency
3745	Beverage and perfume bottles; jars	Cairo, Egypt	Agency
3802	Perfume bottles	Calcutta, India	Agency
3804	Glass bricks, roofing tile and hollow glass prism stones	Singapore, Straits Settlements	Both
3840	Glassware	Tel-Aviv, Palestine	Both
3806	Household glassware	Johannesburg,	Agency
3832	Glassware	Paris, France	Agency
3805	Pressed glassware	Johannesburg South Africa	Agency
3881	Food and cosmetic containers	Stockholm, Sweden	Purchase
3862	Glass tubing	Melbourne, Australia	Purchase
3874	Glassware	Alexandria, Egypt	Agency
3993	Bottles, all types	Guayaquil, Ecuador	Agency
3953	Fancy lotion bottles	Kingston, Jamaica	Purchase
4009	Glass products, inc. wire glass and tiles	Rio de Janeiro	Agency
3985	Non-chip tableware	Santiago, Cuba	Agency
4083	Perfume bottles and cream jars	Singapore, Straits Settlements	Both
4099	Fibrous glass	Buenos Aires	Purchase
4079	Plate glass and mirrors	Guayaquil, Ecuador	Agency
4076	Heat-resisting and laboratory glassware	Rio de Janeiro	Agency
4230	Cut glass and crystal	Rio de Janeiro	Purchase
4233	Glassware	Lima, Peru	Agency
4229	Illuminating ware	Melbourne,	Both
4134	Window and plate glass	Guayaquil, Ecuador	Agency

EFFECT OF HEAT TREATMENT ON COLOR OF GOLD RUBY GLASS

By A. E. BADGER, W. WEYL, and H. RUDOW

ABSTRACT—The preparation of gold ruby glass was described by Kunckel in 1679. A consideration of the works of Faraday, Garnett, Zsigmondy, Svedberg, and others, on gold hydrosols is presented since these studies can be applied in some cases to melts of silicate glasses. In the first part of the present investigation, a series of soda-lime-silica and potash-lead-silica glasses was melted for the purpose of visual comparison. After melting, the glasses were heated for 9 hours at temperatures ranging from 450° to 750°C in order to develop the ruby color. The richest color was obtained in the potash-lead-silica glass. Glasses containing Al_2O_3 required higher temperatures for developing the ruby color, due presumably to the greater viscosity of alumina-bearing glasses. The second part of the study deals with the formation of ruby in a commercial soda-lime-silica glass. Fragments of this colorless glass were heated for various times at temperatures ranging from 575° to 1.000°C. Samples heated at the lower temperatures developed purple tints. Treatment at intermediate temperatures produced ruby glasses. The glasses heated at highest temperatures were blue by transmitted light and had a "livery" color by reflected light. Absorption curves of these glasses were measured with a precision spectrophotometer. These curves can be used to predict the most favorable commercial heating schedule. The various colors produced in this commercial glass were explained as follows: When the quenched (colorless) gold glass is heated near its softening temperature, the aurous compounds decompose and form trivalent ion and metallic gold. The presence of reducing agents in the glass (as stannous ion) aids this reduction. The gold atoms probably grow first as "trees" (as in natural deposits), which cause purplish tints in the glass. These minute "trees" gradually change into more symmetrical forms and the ruby color is produced. Further heat treatment causes these forms to aggregate in clusters, and a blue glass is produced which has a "livery" color by reflected light.

Introduction

The preparation and properties of gold ruby glass were described by the alchemist Kunckel[1] in 1679. Mention of these glasses had been made somewhat earlier in Libavius' "Alchymia." Manufacturing troubles caused the development of gold ruby cased glass which displaced the Kunckel glass so completely that massive gold ruby had to be newly developed near the end of the 19th century. Numerous researches on gold ruby glasses have been made since that time.

The colors due to gold in glass are connected closely with the colors of colloidal gold hydrosols and studies of the latter may be applied in some cases to silicate glasses. Perhaps the best known gold hydrosol is Purple of Cassius, formed by mixing dilute solutions of gold chloride and stannous chloride. A deep red solution results, consisting of a mixture of the hydrosols of gold and stannic acid.

In 1857, Faraday[2] described various colored liquids which he produced by reducing gold chloride solutions with phosphorus. These solutions were sometimes red and sometimes blue or violet. Boiling the solutions made them darker; the red changed to violet and then to blue, and a precipitate formed. Faraday proved that this deposit was gold and concluded that the color in the original solution was due to finely divided gold. He showed the existence of diffuse dispersion in these solutions by concentrating light in the solution with a lens. This effect was studied more fully by Tyndall[3] at a later date. Faraday's conclusion that the material in his solutions was gold in the elemental state has been confirmed by many types of observations, including the X-ray method. In the latter case, Scherrer[4] found gold particles with diameters of only 1.86 mμ—corresponding to 380 atoms of gold—and this particle size[5] was checked by osmotic pressure measurements as 1.6mμ.

Since the particles in red hydrosols and in ruby glasses are so minute, they are invisible under the highest magnification available in microscopes. Siedentopf and Zsigmondy[6] gave great impetus to the study of these small particles by their invention of the ultramicroscope. With the use of their instrument, the colloidal particles appeared as stars on a dark field. These were counted and their size computed.

Colors of Colloidal Gold[7]

Colors of gold hydrosols can be red, blue, or violet. The ultramicrons in the red solution appear green; in the blue solution, they are yellow to reddish brown; while in the violet solution, there are mixtures of both kinds. Besides the above colors, there are brown or yellow solutions. Thus, sometimes Purple of Cassius is first a brown

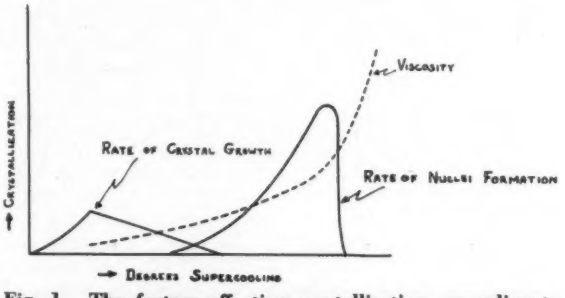


Fig. 1. The factors affecting crystallization, according to Tammann, are the Rate of Nuclei Formation, the Rate of Crystal Growth, and the Viscosity of the Liquid.

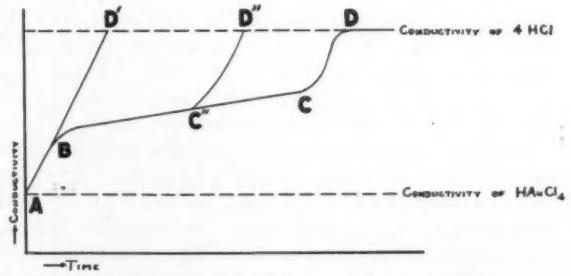


Fig. 2. Formation of ruby color in aqueous solution, correlated with changes in electrical conductivity during the reaction $2\ HAuCl_4 + 3H_2O_2 = 2\ Au + 8\ HCl + 3O_2$ (Svedberg and Nordenson). During the time A B C, nuclei are forming, the ruby color developing from C to D. If nuclei are added, as at B or C″, the ruby color develops rapidly, from B to D′ or from C″ to D″, respectively.

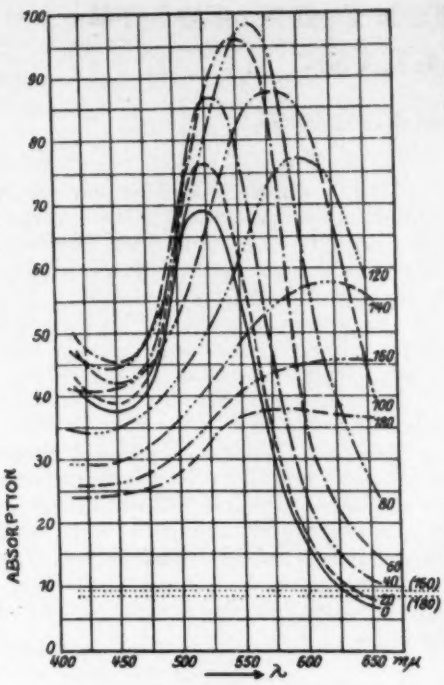


Fig. 3. Left: Absorption curves of gold hydrosols as computed by Mie. The diameter of particles in mμ is shown to the right of each curve.

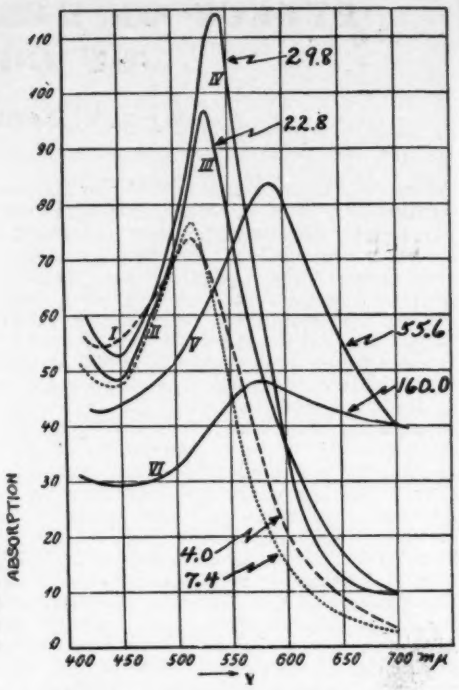


Fig. 4. Right: Absorption curves of gold hydrosols as determined experimentally by Lange. The diameter of particles in mμ is marked with an arrow to each curve.

liquid which changes into red. Also, gold glasses with high lead or tin content often set in dark yellow or brown colors. These colors may be due to the finest subdivision of gold.[8]

Size of Gold Particles

Optical inhomogeneity appears as a distinct haze in colloidal gold solutions containing particles about 100 mμ in size. If the particles are 20 mμ or less, the fluids appear clear by ordinary daylight.[9] In glasses containing gold Zsigmondy[10] found particles as small as 4 mμ in pink glasses, from 10 to 15 mμ in red glasses, from 70 to 103 mμ in blue glasses, and from 131 to 173 mμ in "livery" glasses. Particles 487 to 791 mμ did not color the glasses.

Theories of Color of Colloidal Gold

Ehrenhaft and Parankiewicz[11] explained the colors of colloidal sulphur on the basis of optical resonance of the particles. Maxwell Garnett[12] computed the absorption spectra of gold hydrosols and ruby glasses from the theory which L. Lorenz had developed for optically inhomogeneous media, and in most cases found good agreement with experimental results. Mie[13] gave a complete presentation of the Maxwell equations for a conducting sphere, from which he was able to compute the absorption coefficient, providing that the particles grow in a regular manner and not by the formation of clusters. Even Faraday tried to correlate the color of his gold hydrosols with the particle size. Schubarth[14] thought the changes in color were due to allotropic modifications of the gold.

Zsigmondy[15] states that an explanation of color on the basis of particle size is not possible. Although red colors are usually produced by smaller particles than blue colors, there are sometimes blue solutions which contain less gold than red solutions. Perhaps these are shells formed by gilding gold on another material such as gelatin, which was present in some of these experiments. Also, the shape of the particles and the distance between them affect the color.

In regard to shape, crystal druses or clusters may form. Svedberg[16] found anomalous effects in Brownian movement calculations which he attributed to a departure from spherical shape. Svedberg and Björnstahl[16] found double refraction in gold sols when placed in a magnetic field. These experiments indicated a non-cubic form of the particles. Gans[17] found that the production of disk or rod-shaped particles shifted the absorption maximum to longer wave lengths, thus producing blue colors. Siedentopf[18] observed that pressing gold submicrons between the cover glass and object glass on his ultramicroscope caused greenish particles to change to brown. Finally, various forms of flocks result from the union of primary gold particles and thus produce a change in color.

The influence of the distance between particles was illustrated by an experiment of Kirchner and Zsigmondy[19]. Gelatin films containing colloidal gold appeared blue by

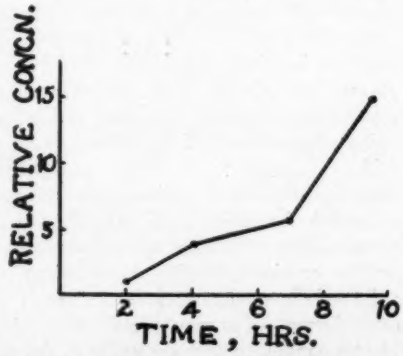
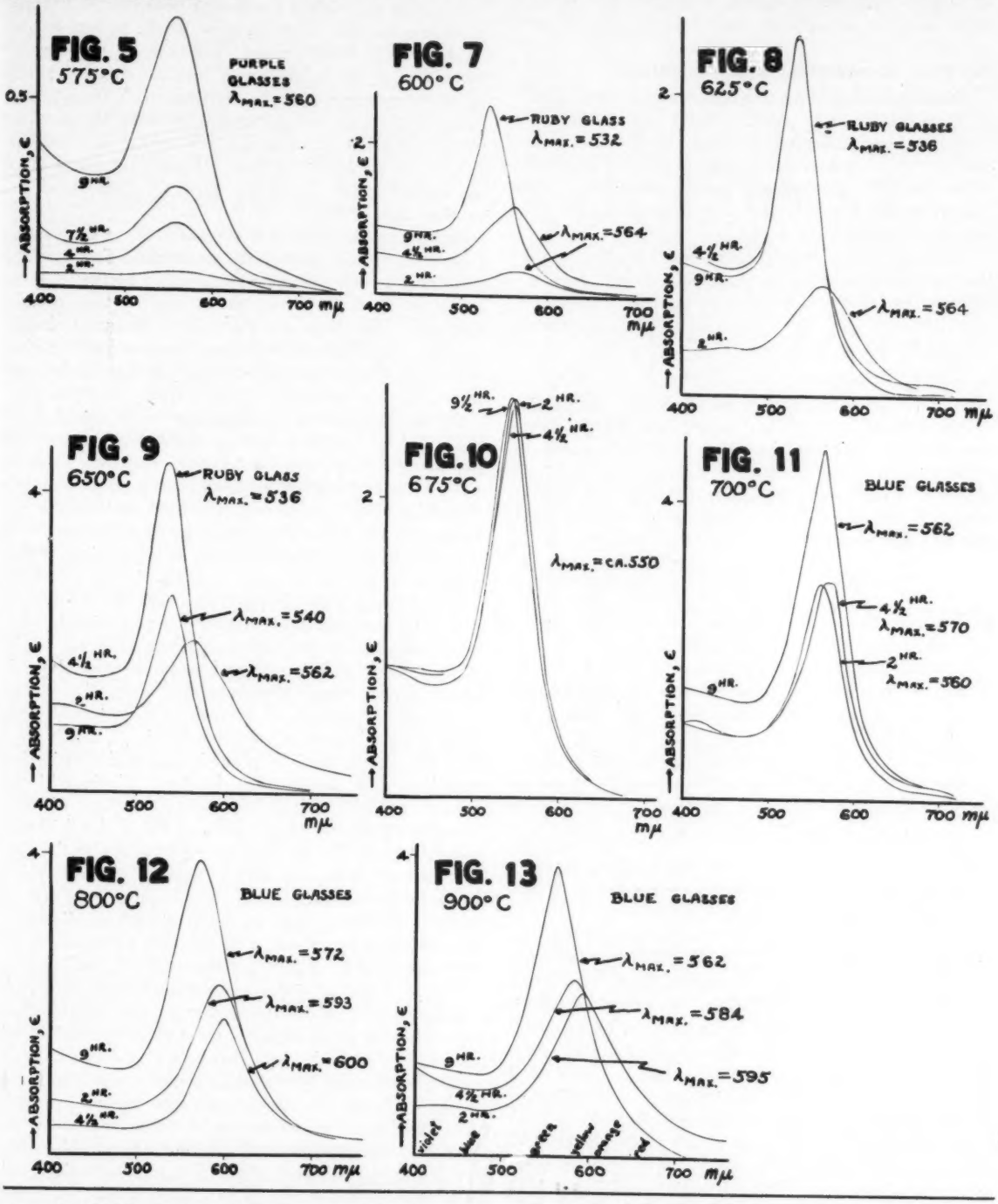


Fig. 6. The relative numbers of gold particles caused by heat treatment at 575°C for various periods.

Figs. 5 and 7-13. Absorption curves of soda-lime-silica gold-containing glass after heating at various temperatures, as designated below the figure number. The absorption is plotted in terms of extinction coefficient (ϵ) for a sample 1 mm. thick. The wave length of light is plotted as abscissa in each figure, while Fig. 13 gives also the colors corresponding to these wave lengths. The time of heat treatment and the wave length of maximum absorption (λ max.) is shown for each curve.



transmitted light. If the gelatin was moistened, it swelled and caused a greater separation of the gold particles. The color then changed from blue to red. The changes could be repeated indefinitely. It would appear that these experiments are not conclusive in regard to the effect of distance between particles, since the refractive index of the medium is changed and this would cause a color change.

The formation of gold ruby glasses is dependent on the temperature and there must be optimum temperatures for the rate at which nuclei form and the rate of growth of the crystalline particles, as illustrated by Tammann's crystallization curves,[20] to which further reference will be made. (Fig. 1.) Svedberg[21] has mentioned that the spontaneous formation of nuclei in a molten substance might be connected with the distribution curves of the

velocities of the molecules. If the velocity is too large, the molecules will not stick together; if it is too low, the chance of meeting will be negligible. Since the tendency of smaller particles to collide is greater than that for large particles, a uniform size of particles is favored.

Previous Experimental Investigations

The growth of gold particles in borax glass was studied by Ehringhaus and Wintgen.[22] Gold was introduced in various minute measured amounts and the decrease in number of particles resulting from various heat treatments was then observed with an ultramicroscope. These authors found a general increase in particle size from red glasses to blue.

When von Smoluchowski's equation[23] for the coagulation of colloidal solutions is combined with Einstein's diffusion equation,[24] the following equation results,

$$\frac{1}{n} = \frac{1}{n_o} + \left\{ \frac{(2}{(3} \; \frac{H\Theta R)}{N\eta a\ )} \right\} t,$$

where n_o is the initial number of particles, n the number of particles at time t; N is Avogardo's number, η is the viscosity, H the gas constant, Θ the absolute temperature, a the radius of the particle, and R the radius of the sphere of attraction of the particle. Ehringhaus and Wintgen found that their measurements agreed with this equation and they determined

$$\frac{R}{a}$$

as about 2.3, that is, the particles must be nearly in contact before they will adhere to each other.

Hatschek[25] verified this equation with gold hydrosols by measurements of the color changes of his solutions, and Mukherjee and Papaconstantinou[26] did likewise by measurements of absorption spectra.

The formation of gold hydrosol was studied in an ingenious manner by Svedberg and Nordenson[27] in the reduction of chlorauric acid with H_2O_2. The reaction,

$$2\ HAuCl_4 + 3H_2O_2 = 2\ Au + 8\ HCl + 3\ O_2,$$

may be followed by measuring the electrical conductivity of the reacting mixture since 4 mols HCl are formed from each mol of $HAuCl_4$.

If no nuclei are present, the course of the reaction plotted against time, may be represented by the curve A B C D (Fig. 2.) During the sudden rise A B, the absorption of blue and violet is less. There are no nuclei, but only a supersaturated solution of gold in water exists. From B to C there is still only a negligible number of gold particles, but nuclei are forming until at C their size is sufficient for them to act as crystallization centers (about 1 or 2 mμ, according to Zsigmondy). At C the characteristic red color of the gold appears and the gold precipitates on these nuclei (C to D) with rapid deepening of the color. If condensation nuclei are added (e.g. gold particles) at B or C″, the reduction occurs rapidly along B D′ or C″ D″.

An alternative explanation of the phenomenon illustrated in Fig. 2 is as follows. The chemical reaction given above is undoubtedly a step reaction, the first of which may be the reduction of trivalent gold to the monovalent form, as

$$3\ Au^{+++} = 3\ Au^{+} + 6\oplus$$

The second step is probably the formation of atomic gold from the monovalent ions, as

$$3\ Au^{+} = Au^{+++} + 2\ Au.$$

The first step would result in a depletion of trivalent gold ions and the yellowish color would be less intense, as observed by Svedberg and Nordenson (A B in Fig. 2.) From B to C, monovalent gold ions are forming atoms, as in the second step of the reaction, while from C to D these gold atoms are aggregating to form the particles which cause the characteristic red color. If condensation nuclei are added (at B or C″), the gold atoms which are formed in the second step grow on these nuclei and produce the red color.

The absorption spectra of red gold sols in comparison with those of ruby glass were investigated first by Zsigmondy and then by others. Long[28] measured the increase in density of color as affected by time of heat treatment. Svedberg and Pihlblad [29] measured absorption spectra of gold hydrosols of various particle sizes and derived an empirical equation to express their results.

On the basis of the electromagnetic theory of light, Mie[13] derived a relation between the absorption spectrum as a function of particle size. The color of colloidal gold sols was explained by the simultaneous action of two properties of gold particles. The gold particles have a sharp absorption maximum in the green and a maximum reflection in the yellow red. Very small particles reflect weakly and absorb strongly, producing ruby solutions. Large particles reflect strongly, the curve of pure absorption becomes lower and flatter, and the solution is blue.

Since light scattering varies with the sixth power of the particle diameter, it is evident how much color depends on the particle size. The theoretical absorption curves of Mie which correspond to various diameters of particles in gold hydrosols are given in Fig. 3, which gives the wave length of light plotted against the extinction coefficient, ϵ, in the equation, $I = I_o e^{-\epsilon cd}$, where I is the intensity of light of initial intensity I_o, c the concentration of gold in volume per cent, and d is the thickness in millimeters. The numbers on each curve give the particle diameter in mμ. It may be seen that the absorption maximum goes toward longer wave lengths as the size of particles increases. For particles of 120 mμ diameter, the absorption maximum is in the yellow and the solution appears blue. Up to particles of 80 mμ in diameter the intensity increases and with larger sizes it decreases.

Lange[30] obtained the absorption curves of gold hydrosols containing particles of measured diameters and found good agreement with Mie's theory. Fig. 4 shows Lange's results, which exhibit a striking similarity to Mie's curves in Fig. 3. Lange also studied gold ruby glasses, in which case the absorption curves would differ from gold hydrosols due to the different dielectric constant and refractive index of water and glass. For a commercial gold ruby glass similar to that to be studied herein, he found a gold content of 1.052×10^{-4} gm. per c.c., the particles being about 60 mμ in diameter.

Present Experimental Melts of Gold Ruby Glasses

It is almost impossible to prepare gold-containing glasses in small-scale melts which will develop a homogeneous color on reheating. Large melts are necessary for the production of homogeneous glasses and such

samples are best obtained from commercial sources. However, the following simple glasses were melted for the purpose of visual comparison:

Glass No.	*Composition of Glass*
1	$Na_2O.2SiO_2 + 0.03\%$ Au
2	$Na_2O.3SiO_2 + 0.0075\%$ Au
3	$Na_2O.CaO.6SiO_2 + 0.0075\%$ Au
4	$Na_2O.CaO.6SiO_2 + 1\%$ $Al_2O_3 + 0.0075\%$ Au
5	$Na_2O.CaO.6SiO_2 + 1.5\%$ $Al_2O_3 + 0.0075\%$ Au
6	$Na_2O.CaO.6SiO_2 + 3\%$ $Al_2O_3 + 0.0075\%$ Au
7	$K_2O.PbO.6SiO_2 + 0.0075\%$ Au
8	$K_2O.PbO.4SiO_2 + 0.0075\%$ Au

The gold was added in the form of alkaline gold chloride solution. About 1/10 of the alkali in the glass batch was introduced as nitrate and the remainder as carbonate.

Samples of these glasses were heated for 9 hours at temperatures ranging from 450° to 750°C., in order to develop the ruby color. Various colors were produced by these treatments. Table 1 illustrates roughly the effects produced by heat treatment for 9 hours at various temperatures. Glasses No. 3, 4, 5, and 6 show the effect of Al_2O_3 in raising the temperature necessary for ruby formation. The richest colors were produced in Glass No. 7. The alkaline silicate glasses (No. 1 and 2) devitrify readily, the deep violet produced in No. 2 glass at 525° being unique among these glasses.

TABLE 1—COLORS PRODUCED IN GLASSES AFTER HEAT TREATMENT FOR 9 HOURS AT VARIOUS TEMPERATURES

R = ruby; L.R. = light ruby; D.V. = deep violet; V = violet; (d) = devitrified; C = colorless; L = livery; B = blue.

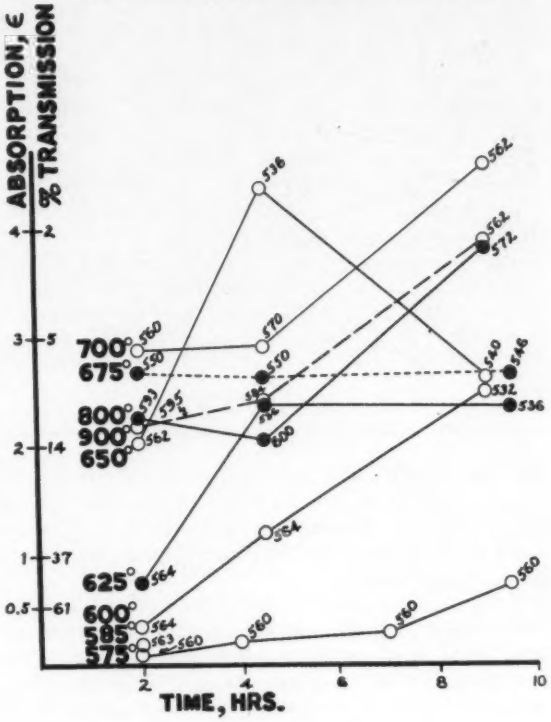
Temp. of Heat Treatment	*Glass Number*							
°C.	1	2	3	4	5	6	7	8
450	R(d)							
475		L.R.					V	
500	R(d)						R	L.R.
525	R(d)	D.V.	C				R	L.R.
550	R(d)	D.V.	L.R.	C	C	C	R	L.R.
575	R(d)	V	L.R.	V	V	C	R	L.R.
600	R(d)	R(d)	R	L.R.	V	V	R	L.R.
625	R(d)	R(d)	R	L.R.	R	L.R.	R	R
650	R(d)	R(d)	L	R	R	L.R.	R	R
700	R(d)	R(d)	L	B	B	B	R	B
750	R(d)	R(d)	L(d)	B(d)	B(d)	B(d)	B	B

Formation of Ruby in Soda-Lime-Silica Glass

A study of the effect of various heat treatments on the formation of gold ruby glass must be made with homogeneous samples. In the following tests a sheet of commercial ruby glass[31] was used, since large scale melts produce more nearly homogeneous glasses.

Samples of the glass about ½ inch thick and 1 inch in diameter were broken from the sheet and heat-treated in an electric furnace, the temperature of which was measured with a Pt-Pt Rh thermocouple placed in contact with the glass surface. After the desired heat treatment, the glass was removed and allowed to cool in air. The sample was then ground and polished and the absorption spectrum measured with a precision spectrophotometer.[32]

Fig. 14. Showing the absorption (ε) and corresponding per cent transmission at wave lengths of maximum absorption of the glasses referred to in Table 3. The temperature of heat treatment is given in large type and the wave lengths of maximum absorption (mμ) in small type.



The original glass samples were practically colorless. The various heat treatments produced color effects which are summarized in the following account. The absorption curves are shown in graphs of extinction coefficient, versus wave length of light.[33] The extinction coefficient, ε, may be defined by the equation, $I = I_0 e^{-\varepsilon x}$, where I is the intensity of light of initial intensity I_0 after passage through a thickness x, and e is the base of natural logarithms. Since the measurements were reduced to a glass thickness of 1 mm., the above equation becomes,

$$I = I_0 e^{-\varepsilon}, \text{ or } \varepsilon = \ln \frac{I_0}{I}.$$

Figs. 5 and 7 to 13 show the values of extinction coefficient, ε, produced by heat treating the glasses for various times and temperatures. The percentage of light transmitted through these 1 mm. samples may be computed from the relation, $\log P = 2 - \frac{\varepsilon}{2.3}$, where P is the percentage transmitted and ε is the extinction coefficient.

At 575°C.—Fig. 5 gives the absorption curves of glasses treated for 2, 4, 7, and 9½ hours, respectively. The glasses have purplish tints, the absorption maximum being at 560 mμ. Also, the curves are all of the same general shape. The curve for 7½ hours can be derived

TABLE 2—COLORS PRODUCED IN A SODA-LIME-SILICA GLASS CONTAINING GOLD BY HEAT TREATMENT AT TEMPERATURES FROM 575° TO 1,000°C AND FOR PERIODS OF 2 TO 9½ HOURS.

P = purple; R = ruby; B = blue.

Temp. of Heat Treatment,	*Time of Heat Treatment in Hours*					
°C.	2	4	4½	7	9	9½
575	P	P		P		P
585	P					
600	P		P		R	
625	P		R			R
650	P		R		R	
675	R		R			R
700	P		P		P	
800	B		B		P	
900	B		P		P	
1,000	B					

from the 9-hour curve by dividing the ordinates of the latter by the factor 2.63. Similarly the 4-hour curve can be obtained by dividing the ordinates of the 9-hour curve by 4.06, while the corresponding divisor for the 2-hour curve is 14.86.

If the intensity of the color in these glasses is due to the formation of particles, then Beer's Law of the absorption of light may be applied and the relative concentrations of the particles obtained. Beer's Law may be stated as, $I = I_o e^{-\epsilon cx}$, where I_o is the initial intensity of a light source and I the intensity after passing through a thickness x of a solution of concentration c. Application of this law to the absorption curves of the glasses referred to in Fig. 5 shows that the relative concentrations of the particles causing the colors are in the proportions—

$$\frac{1}{14.86} : \frac{1}{4.06} : \frac{1}{2.63} : 1 \text{ or } 1 : 3.7 : 5.7 : 14.9$$

A plot of the relative concentrations in these glasses as a function of time is given in Fig. 6.

At 585°C.—Only one test, for 2 hours, was made at this temperature. The absorption maximum lies at 563 mμ.

At 600°C.—Fig. 7 gives the absorption spectra of glasses heated at 600°C. Periods of 2 and 4½ hours produce purplish tinted glasses similar to those heated at 575°C., the absorption peak being at 564 mμ. If the treatment is extended to 9 hours, the absorption peak becomes sharper and shifts to the green. The absorption of blue is increased while that of red is decreased, the result being a ruby tint.

At 625°C.—Fig. 8 shows the effects of treatment at 625°C. A period of 2 hours produces a glass with a purplish tint, the absorption maximum being at 564 mμ. When the periods were increased to 4½ or 9½ hours, ruby glasses with absorption peaks at 536 mμ were produced.

At 650°C.—Fig. 9 shows the effect of heat treatment at 650°C. A period of 2 hours produces a purplish tint ($\lambda_{max.} = 562$ mμ). Heating for 4½ hours produces a ruby glass ($\lambda_{max.} = 536$ mμ) while increasing the time to 9 hours causes a less intense ruby color to form ($\lambda_{max.} = 540$ mμ).

At 675°C.—Heat treatment at 675°C. produces ruby glasses with absorption maxima of somewhat longer wave lengths as shown in Fig. 10. The absorption of blue is decreased also and so these ruby glasses show a tendency to purplish tints. Heating period of 2, 4½, and 9½ hours produced little difference in the absorption curves.

At 700°C.—Treatment at this temperature produces purplish tinted glasses illustrated in Fig. 11.

At 800°-1,000°C.—Treatment at these high temperatures for two hours produces blue glasses with a "livery" reflection. Absorption spectra are given in Figs. 12 and 13 for glasses heated at 800° or 900°C.

The foregoing color effects are summarized in Table 2. The purplish tints produced at lower temperatures are denoted by the letter P, the ruby tints by R, and the higher temperature colors by P (purple) or B (blue). These groupings are only approximate.

Summary of Results

A summary of the results of absorption measurements is given in Table 3, which lists the extinction coefficients

TABLE 3—WAVE LENGTH OF MAXIMUM ABSORPTION AND EXTINCTION COEFFICIENT AT THIS WAVE LENGTH FOR SODA-LIME-SILICA GOLD-CONTAINING GLASS AFTER VARIOUS HEAT TREATMENTS

Temp. of treatment, °C.	*Time of treatment hours*	*Wave length of maximum absorption*	*Extinction coefficient*
575	2	560 mμ	.05
585	2	563 "	.16
600	2	564 "	.32
625	2	564 "	.74
650	2	562 "	2.02
675	2	550 "	2.67
700	2	560 "	2.87
725	2	583 "	3.36
750	2	578 "	3.49
775	2	580 "	2.76
800	2	593 "	2.25
900	2	595 "	2.19
1,000	2	593 "	2.78
575	7	560 "	.27
575	4	560 "	.18
600	4½	564 "	1.17
625	4½	536 "	2.39
650	4	536 "	4.37
675	4	550 "	2.62
700	4	570 "	2.92
800	4	600 "	1.82
900	4	584 "	2.39
575	9½	560 "	.72
600	9	532 "	2.51
625	9½	536 "	2.34
650	9	540 "	2.64
675	9½	546 "	2.67
700	9	562 "	4.60
800	9	572 "	3.89
900	9	562 "	3.89

at wave lengths of maximum absorption. These results are shown graphically in Fig. 14, the wave lengths of maximum absorption being given in small type. Reference to Fig. 14 shows the effects described above, namely:—

(a) At 575°, the constancy of λ max. and gradual deepening of color with time of treatment.

(b) At 600°, the change from purple to ruby.

(c) The similar change at 625°C. with constancy of absorption of glass heated at 4½ and 9 hours.

(d) At 650°, the change from purple to ruby to a ruby of lower intensity.

(e) At 675° to 900°, the variable effects due to larger aggregates of gold. These clusters are large enough to be visible in an ordinary microscope equipped with a substage dark-field condenser (Fig. 15).

Discussion of Results

At the high temperature (ca. 1,300-1,400°C.) used for melting gold ruby glass, the gold probably exists in the ionic form, Au^+ being substituted for an alkali ion in the glass structure. When this glass is quenched, the high temperature equilibrium is retained, gold cations being present in the random network, and a colorless or slightly yellow glass is produced. The electric charges on the gold cations bind these ions to their surroundings and we may consider the gold to be dissolved in the glass.

When the quenched (colorless) gold glass is heated near its softening temperature, the condition of the gold is changed in a marked manner. Aurous compounds are not very stable. They tend to decompose forming the trivalent ion and metallic gold, $3\ Au^+ = Au^{+++} + 2\ Au$.

The presence of other metals may accelerate the formation of gold atoms and reduce all the gold to the metallic state. For example, most batches for gold ruby glass contain tin oxide, which upon dissolving in the glass forms stannous ions. Heat treatment near the softening range promotes the reaction,

$$2\ Au^+ + Sn^{++} = Sn^{++++} + 2\ Au.$$

The gold atoms produced by this reaction are insoluble in the glass. They diffuse and form aggregates.

The experiment of Svedberg and Nordenson [27] on the reduction of chlorauric acid has an analogy in the case of the glass studied here. The purple tint in the glass produced by heat treatment at low temperatures corresponds to the part A B C of the curve of nuclei formation (of Fig. 2). The absorption of blue and violet was found to decrease in the first part of Svedberg and Nordenson's experiment, due probably to the decrease in concentration of $H\ Au\ Cl_4$. In the case of gold ruby glass it seems probable that the nuclei which cause the purple tints in glass treated at low temperatures are irregular shapes of gold. In nature it is found that gold sometimes forms tree-like growths, and by analogy it may be assumed that the nuclei in gold glass may be miniature "trees" which produce the purple color. Further heat treatment allows surface tension forces to come into play and these irregular shapes become more symmetrical in form (as spheres), thus developing the typical ruby color. The tint of ruby which is produced will vary with the refractive index and dielectric constant of the glass.

The formation of copper ruby glass may be explained similarly. The quenched glass contains cuprous ions which react during reheating to form the cupric ion and metallic copper.

Fig. 15. Photomicrograph of gold particles in blue glass produced by heat treatment at high temperatures.

In order to develop bright ruby colors in a glass, it is necessary to control the processes of formation of gold atoms from ionic gold and the aggregation of these atoms to form crystals. Tammann's crystallization curves (of Fig. 1) may be used to illustrate these processes. The curve of nuclei formation corresponds to the reduction of gold ions to form gold atoms. In the experiments described above, these nuclei produced a purple tint in the glass. The aggregation of atoms to form crystals corresponds to the curve of crystal growth, whose maximum occurs at a lower viscosity (higher temperature) than the maximum rate of nuclei formation. The growth of gold crystals in glass produces the ruby color.

The phenomenon of reducing ions in glass to atoms by heat treatment has been demonstrated also in the studies of Weyl[34] on the fluorescence of silver glasses.

Silver ions are much more stable than gold ions in glass as shown by the fact that soda-lime glasses containing less than 0.2 per cent Ag do not "strike" when heat-treated. A reducing agent is necessary to discharge the Ag ion. The resulting formation of Ag atoms is made evident by observing the fluorescence of the glass when illuminated with ultra-violet light. Neither silver ions nor crystals exhibit fluorescence. If glass containing silver ions is heated in an atmosphere of hydrogen at 120°-130°C., the hydrogen diffuses in the glass and reduces these ions to Ag atoms, which give a bright white fluorescence under ultra-violet light.

The absorption curves given in Figs. 5 and 7-13 inclusive may be explained on the basis of this discussion. Treatment at 575°C. produces irregular tree-like shapes of gold which cause purple tints (Fig. 5), the depth of color increasing with time of treatment. At 600°C., treatment for 2 or 4½ hours produced purple glasses (Fig. 7), which changed to ruby if the heating was prolonged to 9 hours. In this case the viscosity of the glass is low enough so that a period of 9 hours is sufficient to allow the irregular shapes of gold to become symmetrical (probably spherical) and the color changes from purple to ruby.

Fig. 8 shows that, at 625°C., a purple glass was produced after a period of two hours. Increasing the time of treatment to 4½ hours produced a ruby glass which did not change in intensity even though the time of treatment was extended to 9 hours. In this case it appears that the purple-forming particles assume symmetrical forms during a treatment of 4½ hours. Additional treatment up to 9 hours does not change the intensity of color because all the original particles have become symmetrical. For commercial practice the "striking" temperature of 625°C. would be most suitable since little variation in color is produced even though the time of treatment varies from 4½ to 9 hours.

Reference to Fig. 9 shows that the purple color produced by 2-hour treatment at 650°C. changed to a deep ruby after 4½ hours. Treatment for 9 hours produced a less intense ruby and the maximum absorption shifted from 536 to 540 mμ. This latter change indicates that the particles produced by the 4½-hour treatment have become larger and less in number after a 9-hour treatment.

At 675°C. (Fig. 10), the glasses produced by 2, 4½, or 9½-hour treatments are all nearly the same color. The wave length of maximum absorption has increased to 550 mμ and the ruby tint is more bluish than the preceding. The explanation for the uniformity of color of these samples is that a treatment of 2 hours at this temperature allows the purple-forming particles to become symmetrical shapes and for the latter to grow. After 2 hours most of the gold ions have been discharged and no significant change occurs although the heating be continued for 9½ hours. The particles are larger than the ruby-forming particles, as evidenced by the greater wave length of maximum absorption.

Treatment at temperatures of 700°C. and higher (Figs. 11, 12, 13) produced blue glasses. In these specimens the purple-forming particles have had time to become symmetrical, to grow into larger symmetrical shapes producing an increase in λ max., and to form clusters of these large particles. These clusters produce a "livery" reflected color and the loss by reflection causes a shift of λ max. to shorter wave lengths as typified in Fig. 12, where a treatment of 2 hours at 800°C. was sufficient to form large particles (λ max. = 593 mμ), which became larger after 4½ hours (λ max. = 600 mμ), and formed clusters after 9 hours with λ max. = 572 mμ.

Footnote References

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• Up to the middle of September, 4,000,000 people had visited the Glass Center at the New York World's Fair. This was 30 per cent of the Fair's total attendance at that time. In spite of the crowds, total damage to glass in the exhibit totaled only $200, part of which included a soap dish stolen from one of the rest rooms.

NEEDED: 247 ACRES OF WINDOW GLASS

A dispatch from Berlin states that more than 10,000,000 square feet of window glass have been ordered by the German Commissioner at Warsaw for delivery before winter to replace the window panes shattered in the bombardment of the Polish capital. To meet the immediate emergency, it is said that Mokotov Racetrack Pavillion, which is made largely of glass, will be taken down. The racetrack survived the siege.

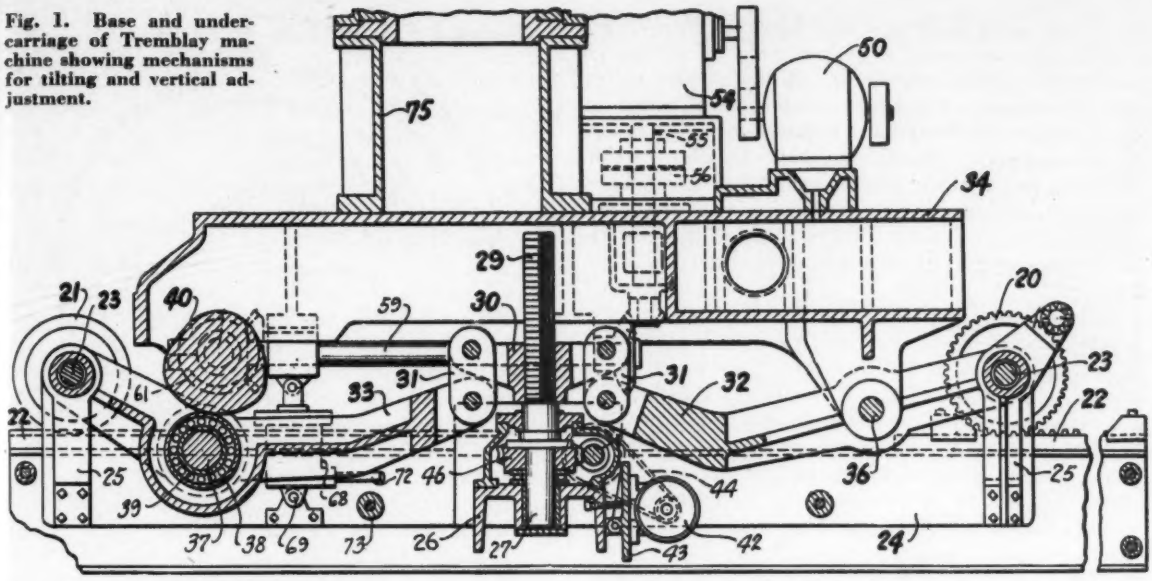


Fig. 1. Base and under-carriage of Tremblay machine showing mechanisms for tilting and vertical adjustment.

TREMBLAY PATENTS A COMPLETE BOTTLE-MAKING MACHINE

U. S. Patent No. 2,168,183, issued to Albert F. Tremblay and assigned to Kent-Owens Machine Co., covers "Apparatus for Gathering and Forming Glass" with many novel and interesting features.

To the crowded and intricate group of patents covering manufacturing activities in the glass industry, the recently-issued Tremblay patent appears to be a most interesting and important addition. The invention relates particularly to improvements in apparatus and processes for gathering and blowing glass in a device where the various mechanisms are mounted upon a rotating turret, and the published objects of the invention are (1) to provide improved means and methods for gathering glass, forming the parison and transferring it to the blow mould; (2) to provide means whereby the blank is accurately shaped and suitably prepared for blowing; (3) to provide means for accurate adjustment of various parts with a minimum of disturbance to the machine as a whole; (4) and to mount the apparatus for rotation about a vertical axis and tilting about a horizontal axis for the purpose of dipping the parison moulds into the glass in a new and improved manner.

In rough outline, therefore, the machine has a series of blank moulds and blow moulds, mounted with their concomitant mechanisms on a turret which revolves continuously about a center column. Instead of being rigidly vertical, however, the center column is mounted in such a way that, at the proper moment in the cycle, it is caused to tilt toward the glass supply, thus bringing the blank moulds on the turret successively into contact with the molten glass. In the space available here it is impossible to cover all the details of this patent, which includes eleven sheets of drawings and 49 claims; however, some of the outstanding features of the Tremblay machine can be understood by reference to the accompanying illustrations.

Fig. 1 is a vertical section through the bottom portion of the machine, the left-hand end of which is toward the glass supply. On the machine base 34 is mounted the turret center column 75, together with motor 50 which drives both the turret and the tilting mechanism through the gear box 54. Beneath the base at one end is a cam 40, driven through gears and shafting as shown, and at the other end the base is pivoted on the shaft 36. An under-carriage 24 is mounted on wheels 20 and 21 and axles 23, the wheels running on rails 22 so that the machine can be moved toward or away from the furnace as desired. The outer ends of levers 32 and 33 pivot on axles 23, the inner ends being hung by links 31 from a nut 30 on a screw 29. The screw is rotatably mounted in a cross-piece in the under-carriage and can be rotated at will by a driving motor, thus causing the nut to be moved up and down. The right-hand lever 32 carries pivot 36 for the base casting and the other lever 33 carries a ball-bearing roller on which the cam 40 rests. It is apparent that rotation of the cam 40 by the driving motor 50 will cause the left end of the base to rise and fall in accordance with the contour of the cam and that this motion will produce movement of a blank mould on the turret to and from the molten glass surface. At the same time the screw 29 may be rotated to move the machine up or down to adjust the amount of blank-mould dip into the glass.

That part of the machine above the bed casting is shown in the vertical section of Fig. 2. The turret is composed of a lower spider 77 and an upper spider 78, these spiders being connected at each mould position by a pair of hollow steel columns 79 (also shown in Fig.

3). Both blank moulds 90 and blow moulds 105 are carried by lower spider 77, upper spider 78 serving as support for various cam levers, air and vacuum valves and blow-heads. The blank moulds are mounted in fixed position on the spider and have no motion except to open and close. On the other hand, the blow moulds 105 have two motions, opening-and-closing and a horizontal motion outward from the blowing position, at the left in Fig. 2, to a position directly over the blank mould, at the right in Fig. 2, and back again under the blow-head.

The neck-ring and parison-transfer mechanism exhibits a great deal of ingenuity, as well as sound mechanical design. It appears at the left in Fig. 2, above the blank mould 90, and also in Fig. 3. The neck ring halves 167 are carried in a crosshead that slides vertically on the hollow columns 79, this crosshead also carrying the center plunger, operated by the admission of air in cylinder 177, and the neck-ring opening mechanism which operates from a cam when the crosshead reaches the top of its travel. Each hollow column (Fig. 3) has an opening 205 near the bottom, each of which registers with separate passages 204 in the crosshead leading to the top of the neck ring. Each column has a poppet valve at its upper end, these valves operating through cams to connect the holes in the columns with supplies of compressed air or vacuum in the upper end of the machine center column.

In Fig. 3 the right-hand column carries the vacuum and the left-hand column supplies compressed air to the neck ring. Compressed air is also supplied to blow-head 240 (Fig. 2) through another cam-operated valve. Other features include a tilting blow-mould bottom 120, ingeniously actuated by vertical movement of the blow-mould hinge pin; a retracting discharge chute 135; and a cut-off knife that is operated beneath the blank mould

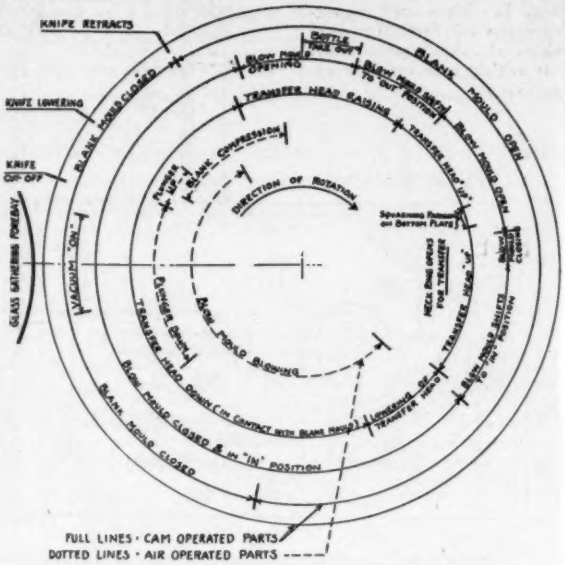
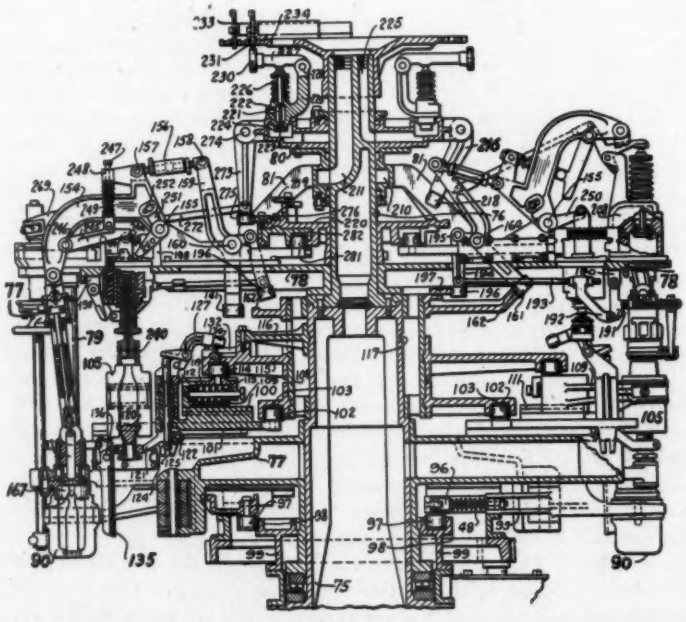


Fig. 4. Diagram showing timed relation of various operations in the cycle of the Tremblay forming machine.

by shaft 262 which has both reciprocating and rotary motion as required.

The unit shown at the left in Fig. 2 is in the gathering position, or the "vacuum on" position of the diagram in Fig. 4. In this position the neck ring is in contact with the blank mould and vacuum is admitted to draw a charge of glass into the mould. As the turret continues to revolve, the machine tilts back toward the vertical position, thus raising the lower end of the parison mould out of the molten glass and the cut-off device is swung across the bottom of the mould to cut off the glass. The turret con-

(*Continued on page* 423)



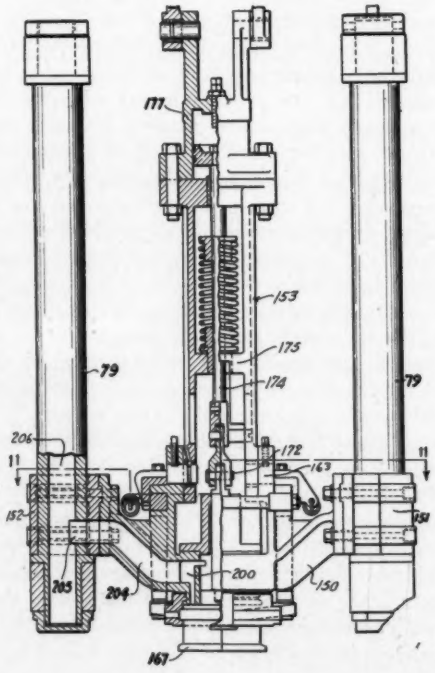


Fig. 2 (left). Vertical section through turret and upper section of the center supporting column. (Right) Fig. 3. Neck-ring mechanism and parison transfer.

GLASS CONTAINER ASSOCIATION MEETS

The Glass Container Association held its semi-annual meeting at the Westchester Country Club, Rye, N. Y., October 24 and 25. Reports from the various committee chairmen tell their own graphic story of the elaborateness of the program which the Association gradually has been developing over a period of years, and which today spreads over a far-flung panorama of research, sales promotion, public relations, traffic and statistical work.

Perhaps the most important activity has been in the line of advertising, research and sales promotion—and here a number of projects under the direction of Scot Faron have been productive of quite astounding results. Space limitations prevent more than touching mere highlights, which nevertheless are suggestive and significant.

Food Containers: Collaborating with The Independent Grocers Alliance, an important organization of retail grocers, a drive was put on that sold 1,126,178 cases of glass packed foods. Some of the statistics are startling: vegetables packed in glass (wide mouth containers) increased 4360 per cent; vegetable juices 533 per cent, and so on.

The Glass Kitchen, now one year old, has developed new uses for glass packed foods, and recipes have been broadcast over approximately half the radio stations of this country to 15 million listeners a week. The Kitchen has developed new and important contacts for the individual company's sales staffs, and uncovered a wealth of information of help to them.

Beer: Here the glass container has been waging war with its rival the tin can—its new weapon, the light weight no-deposit bottle. Investigation into the performance of the new container reveals: (1) the bottle's physical strength is adequate; (2) it has consumer appeal; (3) it has cut into the competition of tin without harm to the Steinie or Export bottle.

One interesting fact demonstrated was that the brewer saves the important sum of $1.68 per barrel of beer when he packages in the no-deposit bottle instead of tin.

Milk: Competition of the paper container is regarded with concern. Although efforts to counteract inroads of paper have been successful to date, it becomes ever clearer that larger appropriations will be needed to push the work more aggressively in future.

Turning to the report of Manager E. G. Ackerman, we find record of an interesting traffic situation that is developing. The I.C.C., as is known, is making another investigation, but this time it is reviewing the whole traffic rate-structure with a view to presenting legislation. Declared objects: (1) To improve the financial condition of rail, water and motor carriers: (2) To prohibit unfair and destructive competition between them; (3) To investigate the relative fitness of each type of carrier for various kinds of traffic (which may result in an allocation of certain traffic to each type); (4) To examine the propriety of different freight levels in different sections of the country.

Because every branch of the glass industries is sensitive to changes in freight rates, the situation is being watched very closely.

Another activity has to do with registration of bottle designs in foreign countries. The Association has interfered with the registration of 17 bottle designs in Cuba that would have competed with American glass manufacturers and has 14 more oppositions pending. The Association has arranged to secure information on all bottle design registrations appearing in major South American countries.

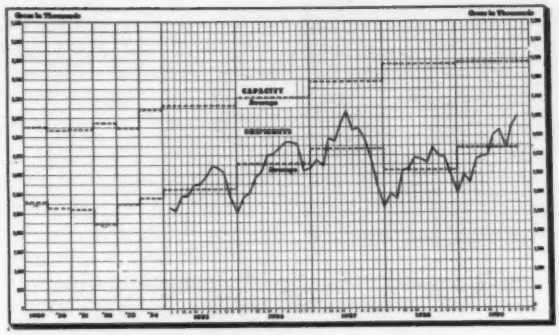


Chart showing the shipment of glass containers. Solid line shows monthly operations. Lower dotted line, the same by years. Upper dotted line is the industry's productive capacity.

Readers of THE GLASS INDUSTRY, and particularly those who are members of the Glass Division, are familiar with the work being conducted by Dr. Preston on the testing of bottles and on bottle fractures. This has been applied to the glass container industry with excellent results, and the fraudulent damage-suit racket, which once loomed as such a menace, is fast disappearing. At these same Butler laboratories, Dr. Ghering has been conducting a school for men connected with container plants, showing them how to interpret the various types of glass fractures, and instructing them in the technique of testing glass. Of importance, too, is the work Dr. Ghering has been doing on the problem of internal scratches in glass bottles.

A report of outstanding interest at all G.C.A. meetings is that of Victor Hall, secretary and statistician. The news at this meeting was exceptionally good. Reference to the chart reproduced on page 417 shows the shipments curve pointing skyward. Thanks to a contra-seasonal upswing in September, shipments are close to the all-time high achieved in June, 1937. For the nine month period, shipments exceeded 1938 by 14.7 per cent and are only 6.21 per cent behind the banner year of 1937. If one would indulge in a little prognosticating, always a little dangerous, it is reasonable to expect that the year 1939 eventually may equal, and possibly exceed the 1937 record. Based on 10 years experience, final-quarter shipments usually total 23.48 per cent of the full year's volume. Assuming history will repeat itself, 1939 shipments may be estimated at 43,655,294 gross, or slightly in excess of 1937. If the September increase, however, represents anticipated buying, as may be quite likely, the final quarter may not come up to these high expectations.

The G.C.A. program of social events this year included a novelty in the way of golf tournaments, the novelty being the introduction of the pari-mutuel system into the game of golf. The experiment was quite successful. A testimonial dinner was held Tuesday evening honoring George S. Bacon and H. G. Phillips.

Personals and Personalities

JOINS MORGAN CONSTRUCTION COMPANY

Mayo D. Hersey has joined the staff of the Morgan Construction Company, Worcester, Massachusetts, as Research Director. Mr. Hersey was for fifteen years connected with the National Bureau of Standards at Washington, D. C., where he organized the Aeronautic Instruments Section, and later the Friction and Lubrication Section of the Bureau. He also served as associate professor or properties of matter at the Massachusetts Institute of Technology, and as physicist in charge of the physical laboratory at the Pittsburgh Experiment Station, U. S. Bureau of Mines. More recently he was head of the test department in the Kingsbury Machine Works.

• Fay V. Tooley has joined the Research Division of the Owens-Corning Fiberglas Corporation at Newark, Ohio. Dr. Tooley received his degree of Doctor of Philosophy in Ceramic Engineering at the University of Illinois last June.

FREDERICK C. CAMERON

Frederick C. Cameron, widely-known official of the Corning Glass Works, died at his home in Corning, N. Y., on September 29. In 1908 he became associated with the Corning Glass Works and at his death was assistant director of sales. Prior to that time he had been connected with the Erie Railroad and through the remaining years of his life he maintained contact and friendship with men in every walk of railroad life. His acquaintance with railroad presidents was large. These associations made him especially interested in sales and service pertaining to railroad signal ware.

ILLINOIS CONFERS Ph.D. ON A. E. BADGER

Alfred E. Badger has received the degree of Doctor of Philosophy in Ceramic Engineering from the University of Illinois. His thesis subject was "The Relation of Physical Composition to Certain Physical Properties of Glass."

Dr. Badger worked in the physiological chemistry laboratory of the Cleveland Testing Laboratories, in the chemical laboratory of National Malleable Castings Co. and in the factory and research laboratory of Grasselli Chemical Co. He received a B.S. degree in Physics from the Case School of Applied Science while working in the glass technology laboratory of General Electric Co., after which he transferred to the company's physics laboratory, in 1924 to its Pitney and then to its Bridgeville glass works. He then joined the Chesterfield Glass Works of British Thompson-Houston Co.

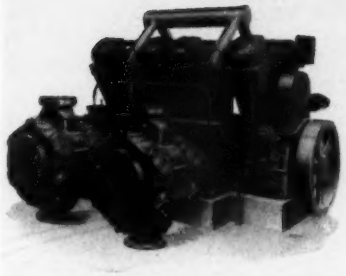
From 1927 until the present he has been connected with the University of Illinois in several departments, receiving an M.S. in Chemistry and this year a Ph.D. in Ceramic Engineering. During a three months' leave of absence in 1937 he worked at the Kaiser Wilhelm Institut fur Silikatforschung.

PAUL G. WILLETTS

Paul Gladstone Willetts, for the last 15 years refractory engineer at the Hartford Empire Company, died at the Hartford Hospital, Hartford, Conn., on October 7 at the age of 57. Mr. Willetts had been associated with the glass industry for approximately 40 years. As a youth he worked with his father in the Willetts Clay Co., Pittsburgh, his native city. Later he joined the Willetts Company in Fairmount, W. Va., where he remained until his move to Hartford. He is the holder of many patents.

Professor Cullen W. Parmelee, head of the Department of Ceramics at the University of Illinois, greets A. K. Bhalla, of Lahore, Cantt, who has come all the way from India to enroll as a graduate student. As guards of honor are the two other foreign students in the department (left) A. R. Rodriguez of Manila, P.I., and V. D. Frechette of Ottawa, Canada.

EQUIPMENT AND SUPPLIES



The new Ingersoll-Rand gas-powered compressor Type "LVG."

NEW LVG COMPRESSOR

INGERSOLL-RAND announces a new heavy-duty, gas-powered compressor known as the "LVG." Designed to fill the growing need for large compact, four-cycle units, the LVG is built in 485 and 650 hp. sizes, using 6 or 8 V-type power cylinders By using only two compressor frames on either side, the inlet, discharge and inter-stage piping and manifolding are simplified, and only two stuffing boxes are required.

The LVG incorporates overhead valves and removable wet-type liners in the power cylinders. All auxiliaries, including the camshaft, the built-in recirculation water pump and auxiliary power take-off are driven from the flywheel end of the shaft, a feature promoting good governing and smooth operation.

Lubrication is full force-feed, with continuous oil cooling and oil filtration. Power pistons have oil-cooled crowns. Governing provides for manual or automatic speed control down to half-speed. Cylinders suitable for pressures up to 5,000 pounds and for vacuum service are supplied.

Additional information on these units may be obtained from Ingersoll-Rand Company, 11 Broadway, New York, or from one of their branch offices.

CATALOGS RECEIVED

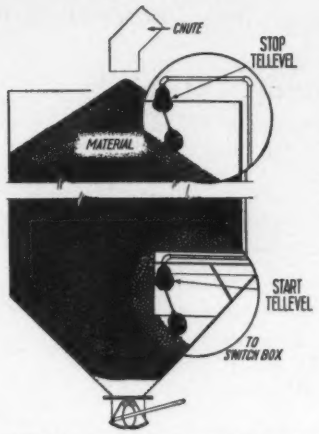
Foxboro Company, Foxboro, Mass. "Thermocouples and Accessories." Bulletin 235. Thirty-six pages of information are conveniently divided into sections that describe the different types of thermocouples, thermocouple assemblies and parts made by this company. Schematic diagrams illustrate various methods of installation. Detailed specifications for various types of thermocouples are included, with full information as to the temperature ranges, and other thermal and mechanical conditions affecting the use of special types.

Brown Instrument Co., Philadelphia. "A New Line of Thermometers and Pressure Gauges." Booklet 2-17. This colorful booklet announces as well as describes three types of Brown thermometers, slated to be "entirely new inside as well as out," the latter reference being to the beautiful, modern case specially designed for this line by Henry Dreyfuss. The thermometers are of three types—vapor, gas and mercury actuated, and include advanced operating characteristics requested by engineers and instrument men throughout the country.

General Refractories Co., Philadelphia. has just published a new book, "Boiler Refractories," an ambitious and comprehensive work in color, with over 50 illustrations. It contains chapters on boiler refractory selection and construction, standards of the American Society of Testing Materials, and many tables valuable for refractory use.

CATALOG & BULLETIN SERVICE

Current catalogs and manufacturers' service bulletins reviewed in this department may be obtained by writing to THE GLASS INDUSTRY.



Tellevel in operation, controlling level of material in bin.

NEW CONTROL OF STORAGE

STEPHENS-ADAMSON MFG. CO., Aurora, Ill., has put on the market "Tellevel," a control device that starts and stops conveyors feeding bulk materials to bins or hoppers, and that opens and closes valves feeding liquids into tanks.

Operation is normally entirely automatic, but, by a simple change in wiring, the Tellevel can be made to keep the flow of material stopped or continuous until the control switch is thrown.

The new dust-tight type, explosion-proof design of the Tellevel consists of a multiple electrode sealed mercury switch so mounted that tipping it in any direction will break the electric current. A polished aluminum bell provides the dust-tight housing for the switch and electric wiring.

Mounting for the mercury switch is a fiber holder, screwed to the top of the tipping rod. This rod is pivoted in a rubber diaphragm . . . its lower end fitting into the globular polished aluminum bell. Bell housing is supported on the end of a half inch conduit pipe.

Manufacturing has just begun in the new plant of the Toledo Scale Company, the largest plant in the world devoted to making automatic weighing devices. The factory covers 250,000 square feet, yet the plant has been laid out with such efficiency that the maximum haul is 200 feet.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	43.00	46.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Borax ($Na_2B_4O_7 10H_2O$)	lb.	....	....
Granulated	In bags, lb.	.0215	.027 -.0295
Powdered	In bags, lb.	.024	.0295-.032
Boric acid (H_3BO_3) granulated	In bags, lb.	.048	.054 - .0565
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.0865-.0875	.0925
Synthetic (Artificial)	lb.	No supplies available	
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	28.00-29.00	....
In bags	ton	29.60-30.60	38.00-40.00
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0755	....
In 5 Ton lots	lb.	....	.08½
Less than 5 Tons	lb.	....	.09
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	8.50	8.50
Burnt (CaO) ground, in bulk	ton	7.00	....
Burnt, ground, in paper sacks	ton	9.00	9.00
Burnt, ground, in 180 lb. drums	Per drum	1.60	1.70
Kiln Dried ($CaCO_3$) 10x30 mesh	ton	1.75	....
Kiln Dried ($CaCO_3$) 16x120 mesh	ton	1.75	....
Nepheline Syenite, f. o. b. shipping point	ton	12.00-14.00	....
Potassium carbonate—			
Calcined (K_2CO_3) 96-98%	lb.	.065	.0675
Hydrated 80-85%	lb.	.055	.0575
Salt cake, glassmakers (Na_2SO_4)	ton	15.00-15.50	25.00
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb	.95	....
In barrels	Per 100 lb.	1.35	....
In bags	Per 100 lb.	1.10	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls	Per 100 lb.	....	2.50-2.90
95% and 97%			
Bulk	Per 100 lb.	1.35	....
200 lb. bags		1.415	1.44
100 lb. bags		1.45	1.475

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	.029	.03½
Aluminum oxide (Al_2O_3)	lb.	.07	.09
Antimony oxide (Sb_2O_3)	lb.	No supplies available.	
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03	.03½
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	Open price.
Pyrophyllite, (20% Al_2O_3)	ton	9.00	12.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¾-.05	.05½-.06
Tin Oxide (SnO_2) in bbls	lb.	....	.52
Titanium Oxide (ceramic grade)			
In bags	lb.	.12	.12¼-.12¾
In barrels	lb.	.12¼	.12½-.13
Zinc Oxide (ZnO)			
American process, Bags	lb.	.06¼	.06½
White Seal, 150 lb. bbls	lb.	.08¼	.09
Green Seal bags	lb.	.08	.08¼
Domestic White Seal bags	lb.	.08½	.08¾
Red Seal, bags	lb.	.07½	.07¾
Zircon			
Refined Granular (Milled .01-.02c higher)		.06½	.07-.08

Coloring Materials

		Carlots	Less Carlots
Barium selenite ($BaSeO_3$)	lb.	....	1.40-1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	.95
Cerium hydrate—			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls	lb.	....	.25-.28
Chromite (99% through 200 mesh)	ton	35.50	40.00
Chromite ore (air floated)	ton	55.00	58.00-73.00
Cobalt oxide (Co_2O_3)			
In bbls	350 lbs. or more, lb.	....	Open price
	Less than 350 lbs., lb.	....	Open price
Copper oxide—			
Red (Cu_2O)	lb.	....	.165
Black (CuO)	lb.	....	.18-.19
Black prepared	lb.	....	.22
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.0425-.09
Black (Fe_3O_4)	lb.	.04½	.09
Iron Chromate	lb.	....	.035-.05
Lead Chromate ($PbCrO_4$) in bbls	lb.	....	.145
Manganese, Black Oxide			
In Paper bags	ton	62.50	65.50
In Burlap bags	ton	64.25	67.25
In Casks	ton	66.50	69.50
Neodymium oxalate, 50 lb. drums	lb.	....	3.50
Nickel oxide (Ni_2O_3), black	lb.	....	.35-.40
Nickel monoxide (NiO), green	lb.	....	.35-.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	.08¾	.09-.09¼
Powdered	lb.	....	.09½-.09¾
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	....	.27
Powder blue	lb.	....	.18-.20
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) In 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06¾	.07-.07¼
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	.08¼	.08¾-.08¾
Sodium selenite (Na_2SeO_3)	lb.	....	1.50-1.65.
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.75-1.80
Yellow	lb.	....	1.75-1.80
Sulphur (S)—			
Flowers, in bbls	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls	Per 100 lb.	2.90	3.25-3.65
Uranium oxide (UO_3) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	....	2.65-2.75
Yellow orange	lb.	....	1.75-1.80

Polishing Materials

		Carlots	Less Carlots
Emery, Turkish	lb.	.063	.07
Pumice Stone,			
American Ground Italian FFF, FF, F	lb.	....	.03
0, 0½, ½, 1.	lb.	....	.04
Putty Powder	lb.	Open price.	
Rotten Stone, (Domestic)	lb.	....	.03½
Rouge, Red	lb.	....	.16
Black	lb.	....	.18

STRIKE-LOSS FORMULA

To estimate accurately the economic losses resulting from strikes is difficult. However, in any strike, one factor readily ascertainable is the actual wage loss in dollars and cents of the employees.

To obtain the loss item indicated, multiply the total wage loss in the given strike by the multiplier shown after the item below:

Employers' overhead loss	1.315
Employers' added expense	0.147
Materials in process tied up	2.954
Value of orders tied up	5.558
Local business losses in strike area	1.038
Losses to directly related and affiliated businesses	8.184
Total tied up business transactions (including wage loss)	20.4563

The above formula has been worked out from figures submitted by Gustav Stahl, executive secretary of the National Bureau of Economic Research, to the U. S. Senate subcommittee on finance. Mr. Stahl's estimate of the country's economic losses sustained from strikes during the years 1933 to 1937 inclusive, in millions of dollars, were: Wage loss, 345.8; employers' overhead loss, 554.7; employers' added expense, 51; materials tied up, 1,021.5; orders tied up, 1,922; local business losses, 358.8; losses to directly related and affiliated businesses, 2,830; total tied up business transactions, 7,083.8, or $7,083,800,000—over $50 for each person in this country. The foregoing formula was obtained by using the amount of wages lost as a divisor of the other items.

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Important Executive

HIS duties will be to take complete charge of our manufacturing operations, coordinating this activity with sales and research, and to act as a major officer of the Company in determining all basic policies and methods.

Although his previous or present experience may not exactly parallel the requirements of this position, the applicant must have a business record demonstrating equivalent executive qualities that show him capable of filling a key position in a large organization—leadership, analytical ability, resourcefulness, tact, and vision. He must have the force and character to command the respect of his associates, who will be the officers and directors of the Company, and the courage to do battle for his convictions in his deliberations with these men.

The salary will be adequate to attract a man of these high qualifications, and there will be other compensation that will limit both the present and the future only to the ability of the man himself.

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SOLVAY DUSTLESS CALCINED 98-100% POTASSIUM CARBONATE

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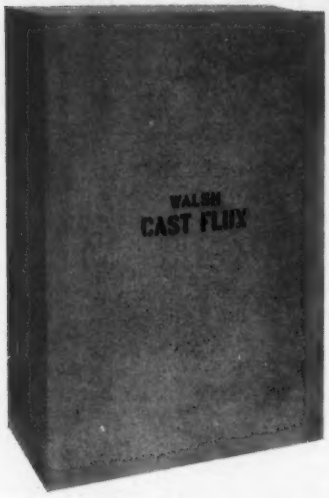

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BROADCASTS THE STORY OF GLASS

John D. Biggers, president of the Libby-Owens-Ford Glass Company, has been telling the world about glass. Interviewed by Under Secretary of Commerce Edward J. Noble in a radio broadcast, Mr. Biggers outlined some of the contributions which this industry has made to our social and economic welfare. Glass, he said, has created new property values by the rehabilitation of business areas; made home life more enjoyabl by the better lighting, and increased beauty of the surroundings.

Mr. Biggers said he had no patience with the idea that it would require a new industry to restore economic prosperity; existing industries had that power within themselves. For example, it was no accident that created safety glass, fibreglass, glass cooking utensils; but millions of dollars invested in research over long periods of time together with ingenuity and research. An what the glass industry had done, other industries could do as well.

Glass had reduced unemployment, the number of its wage earners increasing from 52,818 in 1899 to 79,051 in 1937, this despite a machine revolution within the industry. Average wages had increased from $512 to $1,285 per man in this period, and the total wage bill quadrupled from $27,084,701 to $101,587,694. In these same 37 years, the value of the glass industry jumped from $56,500,000 to $387,700,000—a sevenfold increase.

The glass industry holds great promise for the future, concluded Mr. Biggers. "The future of the industry is just now unfolding. The basic resources which men have developed in this industry have been primarily those of the human mind and spirit. What has been achieved can be achieved again and again. It takes no prophet to see that we are just now coming into the Age of Glass. Certainly, the great building development which must come, and not in the too distant future, will be featured by the widest areas and the most varied uses of glass which construction has ever known. Glass is in step with man's natural progress today. The whole movement toward natural living is a turning to the light, and glass is the one structural medium of light which has proved satisfactory in all climates, and at all temperatures.

BRITISH SOCIETY DEDICATES NEW HOME

Advance proofs of the *Journal of the Society of Glass Technology*, received through the kindness of Dr. Duncan and Prof. Turner, contain an interesting account of the dedication of the new buildings of the Department of Glass Technology at Sheffield, England. Readers of THE GLASS INDUSTRY will recall when the foundation stone was laid in November, 1937, amid impressive ceremonies.

From the *Journal* we learn that the plans for the present structure were drawn from a rough sketch prepared by Prof. W. E. S. Turner. The site is located about "six minutes' walk" from the main buildings of the University of Sheffield, where an old stone house still remains as the nucleus of the building scheme. The entire domain is called Elmfield.

Quite naturally, a great deal of glass in many of its most modern forms are to be found in the construction and in decorative use. A glass curtain was used in the

dedication ceremony; there are stained glass windows, glass block and tile, and even glass plaques. Many of these are quite unusual and in themselves deserving of lengthy description. The present structures cost £41,000. Further construction is contemplated when additional funds can be secured.

During the ceremonies attending the unveiling of a commemorative tablet, Mr. Godfrey Pilkington proved himself quite a wit. He referred with regret to the fact that the foundation block contained a few seeds; but, said he, he noticed that in the past 20 months the seeds had sprouted into a noble block of buildings.

The full account, containing many pictures of the premises, will appear in the August issue of the *Journal*.

TREMBLAY BOTTLE MACHINE

(*Continued from page* 416)

tinues to revolve, carrying the parison mould beyond the gathering pool and at the proper time the cut-off knife is lowered slightly, the plunger is raised, and air is admitted through the left-hand column to form a preliminary blow opening in the blank, the cut-off knife remaining in position a short distance below the mould to limit the elongation of the blank at this time.

Thereafter, the knife is retracted, the blank mould is opened, and the crosshead rises to its upper position carrying the parison in the neck ring. The open mould now moves out and closes around the parison. It is preferable to have the neck ring raised slightly higher than the top of the blow mould at this time and lowered just before the blow mould is closed. This action squashes the parison on the mould bottom and facilitates proper formation of the article. The neck ring now opens, releasing the blank and the blow mould is returned to its inner position beneath the blow-head where the finish blowing of the article is completed. With the completion of the blowing the mould is opened, the mould bottom is tilted and the finished article is discharged by the chute.

Practically every phase of the operation of this machine seems to be adjustable, both in timing and extent, and adjustment of one part can be accomplished without interfering with other operations. Accessibility for repair, replacement or adjustment has also been considered in the location and detailed design of the working parts.

SYMPOSIUM ON TEMPERATURE

A symposium on Temperature—Its Measurement and Control in Science and Industry—will be held November 2, 3, and 4 in the Hotel Pennsylvania, New York. The meeting is being conducted under the auspices of the American Institute of Physics, the National Bureau of Standards, and the National Research Council, with officers and committees of various scientific organizations cooperating, among them the American Ceramic Society. Professor F. H. Norton will preside over the session on Non-Ferrous Metals and Ceramics on Thursday evening. One of the most important purposes of the symposium is stated to be the opportunity it will afford to exchange fundamental information among industries. Copies of the complete program containing titles, authors and full abstracts of papers may be secured by addressing: Temperature Symposium Committee, American Institute of Physics, 175 Fifth Avenue, New York.

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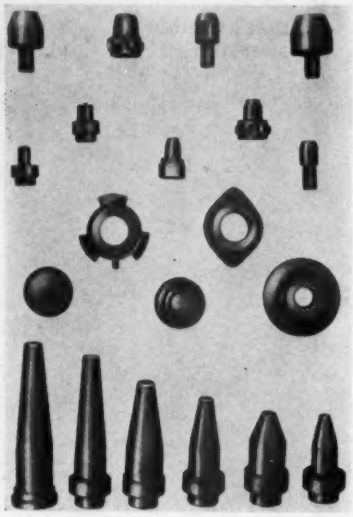

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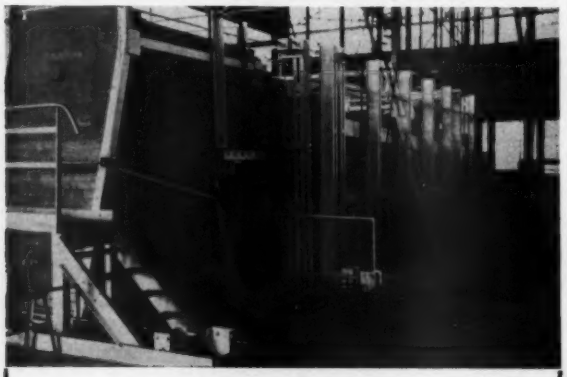

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GLASS vs. PAPER MILK CONTAINERS

Rivalry between glass and paper interests over the merits of their respective containers has resulted in a great deal of confusion in the minds of industry and of the public. Being unsupported by factual data, the claims of either side have lacked conviction.

In an effort to get at the facts, the Glass Container Association has gone into the twelve major markets where both glass and paper have been given a fair trial and assembled for the first time actual "case histories." These have been printed in a 24-page booklet "Your Milk Container." Here the subject matter has been very skillfully classified for quick consumption into three sections: Facts about Milk Marketing, Case Histories of Milk Markets, and Comparison of Container Costs. One fact the booklet demonstrates is that if the twelve billion units of milk delivered in bottles last year had been packaged in single-service containers, the nation's milk packaging bill would have been 13 times the amount actually spent on new milk bottles.

On the basis of this investigation, the Glass Container Association draws the following conclusions:

(1) The glass bottle for milk has never been seriously threatened in any market where retail selling prices gave it equal competitive opportunities with other containers.

(2) Markets which have been offered a free choice between glass and paper at the same price have decisively rejected paper; these provide the most practical proof of consumer preference for the glass container.

(3) Cost studies showing approximately 1 cent higher packaging and wholesale delivery costs per unit in paper than in glass are being corroborated in practical dairy experience.

(4) Glass bottles and the investment they represent have given markets a stabilizing influence not exerted by substitute containers.

L-O-F THIRD QUARTER REPORT

In reporting to stockholders on the condition of the Libby-Owens-Ford Company, President John D. Biggers notes a decided improvement for the first nine months of 1939 and forecasts an excellent final quarter. Earnings for the first three quarters of the year were $1.56 a share on the common stock against 17 cents last year. Since September 1 there has been an abnormal demand from the building and mirror industries. Whether this merely represents anticipatory buying or reflects a corresponding consumer demand, Mr. Biggers is unable to say; but he is depending upon normal seasonal activity in the automotive industries to fulfill his end-of-the-year expectation. L-O-F has maintained substantial reserves against investments in foreign glass companies. As its export trade has been confined to Canada for many years, the company has not been adversely affected to date by conditions abroad.

• Corning Glass Works has obtained a permanent injunction restraining two New York City hardware retailers from advertising or selling any products bearing the Pyrex trade-mark at less than the prices stipulated in the Fair Trade Agreements signed last June in New York State.

1939 CHEMICAL INDUSTRIES EXPOSITION

Advance publicity from the offices of the Chemical Industries Exposition, which will be held as usual in the Grand Central Palace, New York, in early December, indicates that this year's show will meet all expectations in depicting the panorama of chemical progress during the last two years. The exposition will feature chemicals, chemical raw materials, and fabricated materials for use in industrial operations, in terms of their manufacture and use.

The field of precision instruments will include the latest types of temperature and pressure measuring devices. Included will be a recorder controller pyrometer for throttling fuel heat, and a new line of rectangular-case indicating recorders and controllers with nine, ten and twelve inch charts for temperature and pressure. other interesting instruments of precision will include a machine to determine plasticity. This is described as the first machine to use the dynamometer principle and an elaborate leverage and scale system in order to determine accurately, under controlled temperature conditions, the plasticity of all sorts of pliable material from syrupy substances to materials as tough as unvulcanized rubber. Plasticity is automatically recorded in terms of centimeter grams of torque. Measurement by this instrument is said to provide an accurate index to changes in the material caused by different temperatures, addition of ingredients or fillers, breakdown action of catalysts, etc. A new recording viscosimeter offers a spiral drive thermometer, the first of its kind ever made, which governs a constant speed temperature increase of the suspension to be measured. Operating between room temperature and 150°C., this viscosimeter is said to be the first instrument in which it is possible to obtain combined temperature-viscosity curves of viscous material.

In the field of drying agents, a soluble anhydrite will be shown to be the result of research on the fundamental nature and behavior of hydrates of calcium sulphate. Measurement of hydrogen ion concentration, related to process control in many industries, will be demonstrated by what is said to be the first commercially successful unit for continuous p_H measurement and control using the glass electode. Materials of construction cover a wide range of applications, including acid and corrosion proof linings.

U. S. BUYING MANGANESE ORE

Among the many bids on manganese ore received by the United States Government under its strategic minerals program, was one from Soviet Russia, which has offered to supply from 5,000 to 200,000 tons. The bid contained a number of restrictions; one, that the sellers would not be responsible for delay and another, that delivery could be made immediately or within the next 10 years. Minimum manganese content of the Soviet ore was guaranteed to be 61 per cent, which is 3 per cent better than U. S. specifications. Other bids were received for South African and Cuban ore.

• Retail sales of motor vehicles increased 42 per cent during the first nine months of 1939 over the corresponding period of 1938.

• Today, looking into the future and finding the answers to tomorrow's problems is just a matter of sound, thoughtful research. In glass and ceramics, it means developing chemicals and colors that will be able to meet tomorrow's requirements . . . it means *anticipating* new products, new uses, new advancements —and being *ready* for them.

When you run into a tough problem involving colors or chemicals—remember that Drakenfeld research may have found the answer for you already . . . and that Drakenfeld technologists are ready to serve you quickly, willingly, without any obligation whatever on your part. Just write.

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METALLIC OXIDES AND CHEMICALS

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Cadmium Oxide
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Cerium Hydrate
Chrome Oxide Green
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Copper Carbonate
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Nickel Sulphate
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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF MARCH 3, 1933.

THE GLASS INDUSTRY, published monthly at 11 West 42nd Street, New York, N. Y., for October 1, 1939, State of New York, County of New York, ss:

Before me, a Notary Public in and for the State and County aforesaid, personally appeared John T. Ogden, who, having been duly sworn according to law, deposes and says that he is the Publisher of THE GLASS INDUSTRY and that the following is to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: John T. Ogden, 11 West 42nd Street, New York, N. Y.

2. That the owners are: Ogden-Watney Publishers, Inc., 11 West 42nd Street, New York, N. Y.; John T. Ogden, 11 West 42nd Street, New York, N. Y.; Katherine Waller Ogden, 11 West 42nd Street, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed)

JOHN T. OGDEN, *Publisher.*

Sworn to and subscribed before me this 10th day of October, 1939.

Joseph M. Charlebois
Notary Public, Queens Co. Cl'k No. 318, Reg. No. 131 N. Y. Co. Cl'ks No. 38, Reg. No. O-C-24 Kings Co. Clerk No. 109, Reg. No. 105 Bronx Co. Cl'ks No. 2, Reg. No. 2C40 Certificate filed in Richmond County. (My Commission expires March 30, 1940)

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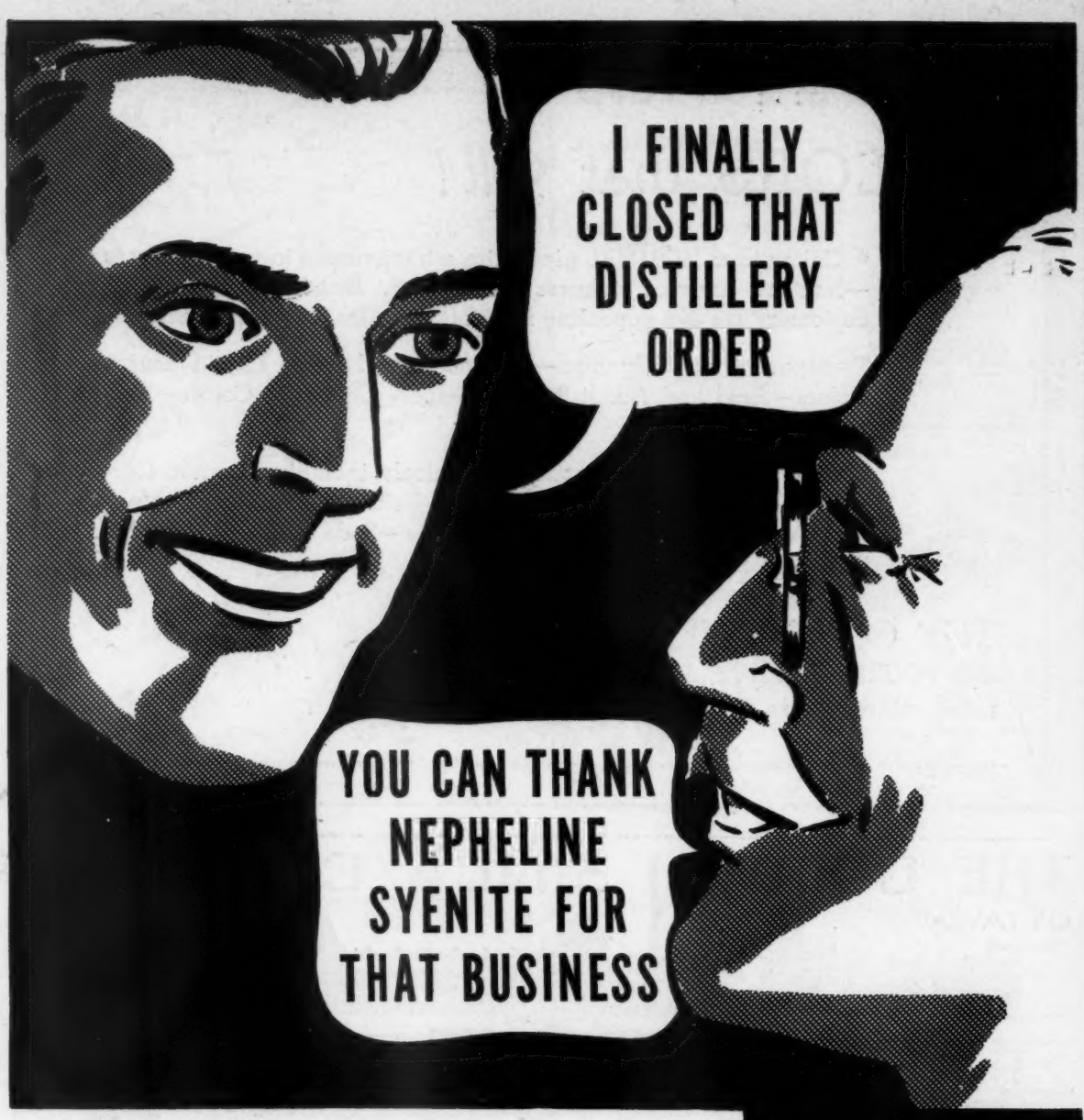

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